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Spring Temperatures in Relation to Laying Dates and Clutch Size of the Blue Tit (*Parus caeruleus*) in Croatia

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ABSTRACT.—This study was based on spring temperatures, laying dates, and clutch size of the first nesting attempt of the Blue Tit (*Parus caeruleus*) from 1982 to 2004 in Hrvatsko Zagorje rural area (46° 00′ N, 15° 55′ E), Croatia. The results suggest that timing of breeding of the Blue Tit is influenced by spring air temperatures. There was a significant correlation between spring temperature and years, consistent with a global warming trend. The date of clutch initiation in the Blue Tit population studied did not decrease over a 23-year period. Correlations between spring temperatures and clutch size, and year and clutch size were not significant. *Received 13 January 2006. Accepted 7 October 2006.*

Several authors have discussed use of birds (and other organisms) as sensitive biomonitors for climate change (e.g., Winkler et al. 2002, Parmesan and Yohe 2003). Climate change affects bird migration (e.g., Sokolov and Payevsky 1998, Dolenec 2003) and breeding phenology (e.g., Dunn and Winkler 1999, Sergio 2003), and it is likely that these trends are caused by global warming. However, it is necessary to conduct relevant studies on more species in extensive areas to confirm changes are occurring (Koike and Higuchi 2002).

I investigated the long-term variation in laying dates and clutch sizes of the Blue Tit (*Parus caeruleus caeruleus*) (Vaurie 1959) to examine breeding phenology in relation to spring temperatures. The Blue Tit is a common and sedentary species in northwestern Croatia.

STUDY AREA AND METHODS

This study was conducted during the breeding seasons of 1982 to 2004 in deciduous forest (45° 50′ to 46° 00′ N, 15° 50′ to 16° 00′ E) in the Hrvatsko Zagorje area of northwestern Croatia. All records used in this study were from nest boxes. The internal dimensions of the nest boxes were 120 × 120 × 230 mm, and the front section had a 29-mm diameter hole. All nest boxes had a sliding top to enable observers to monitor nesting. Only clutches from pairs that bred in nest boxes were included. Nest boxes were placed 50 m apart on deciduous trees (2.5–5 m above the ground) and were inspected every 1–5 days. The dominant tree species were oak (*Quercus robur*) and hornbeam (*Carpinus betulus*); other tree species that occurred in low proportion included: common maple (*Acer campestre*), ash (*Fraxinus angustifolia*), and common elm (*Ulmus minor*). The number of nests in the sample varied from year to year (range = 19 to 39 nests per year, mean = 30.4 nests per year). Blue Tits in this area rear only one brood per year. Renest clutches due to nesting failure were not included.

Spring air temperature was calculated as the mean of February, March, and April temperatures. Mean (± SD) monthly Mokrice air temperatures for February, March, and April (1982 to 2004) were provided by the Meteorological Office in Zagreb (Feb, mean = 1.7 ± 3.12° C, range = −4.2 to 6.1° C; Mar, mean = 6.1 ± 2.26° C, range = 0.9 to 10.2° C; Apr, mean = 10.6 ± 1.35° C, range = 7.9 to 13.8 °C).

RESULTS

I calculated Pearson's correlation coefficient between clutch initiation and mean spring temperatures to examine long-term trends in egg-laying dates. There was a significant correlation between timing of clutch initiation and the mean spring temperature ($r = -0.483$, $P = 0.019$, $n = 23$; Fig. 1). The relationship between mean laying date (y) and spring air temperatures (x) was $y = 49.9 - 2.09x$, indicating that laying dates decreased by 2.09 days per 1° C. There was no significant correlation between mean clutch initia-

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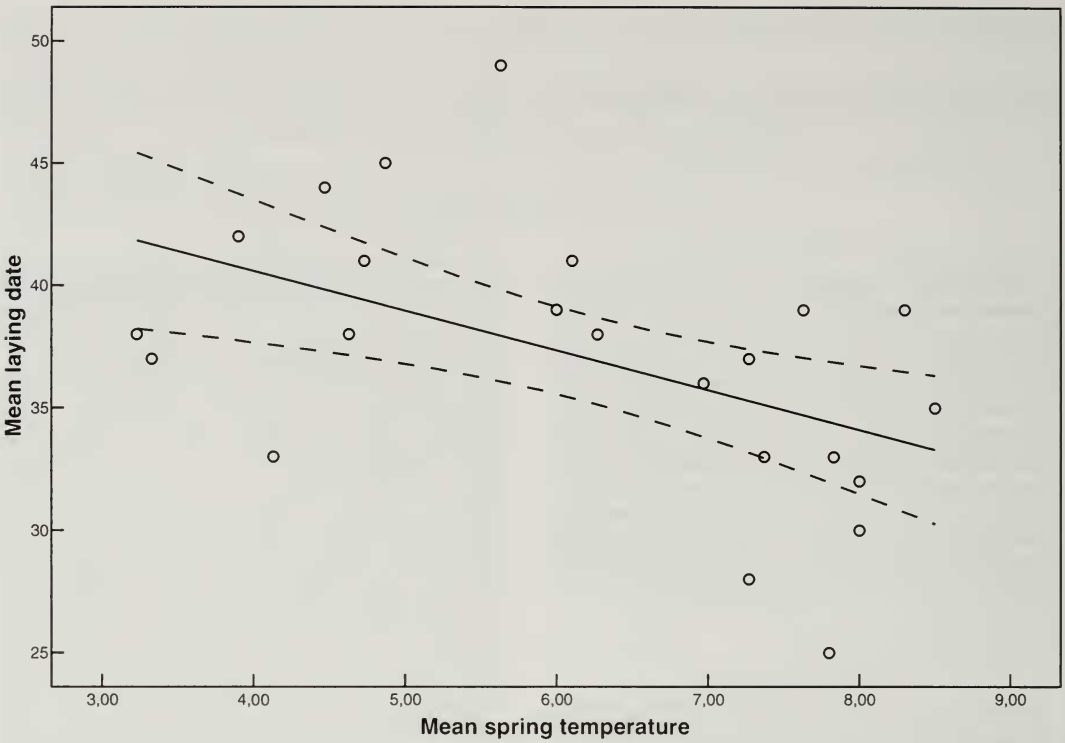

FIG. 1. Correlation between laying date and spring temperature for Blue Tits in Mokrice, Croatia, 1982 to 2004 (Pearson's correlation coefficient: $r = -0.483$, $P = 0.019$, $n = 23$; $y = 49.9 - 2.09x$; for date, 1 Mar is day 1) (dashed lines represent borders of 95% confidence interval).

tion date and the entire research period (from 1982 to 2004; $r = -0.075$, $P = 0.734$, $n = 23$). The correlation between mean spring temperatures and year was significant ($r = 0.417$, $P = 0.048$, $n = 23$; Fig. 2). The relationship between spring air temperatures and year ($y = -203.08 + 0.11x$) indicates that spring air temperatures are rising 0.11° C per year. The correlation between spring temperatures and clutch size was not significant ($r = 0.306$, $P = 0.156$, $n = 23$). Thus, clutch size in the Blue Tit population studied did not advance over a 23-year period ($r = 0.361$, $P = 0.091$, $n = 23$).

DISCUSSION

My results suggest that timing of breeding of the Blue Tit is influenced by spring air temperatures. It has been shown that many bird species are egg laying progressively earlier in response to global warming. For example, from 1971 to 1995, significant trends toward earlier laying dates were found in 20 bird species in the United Kingdom (Crick et al. 1997). This pattern is confirmed by long-term studies of bird populations (e.g., McCleery and Perrins 1998). According to Crick et al. (1997), earlier nesting could be beneficial if juvenile survival is significantly enhanced before winter; conversely, birds may be adversely affected if they become unsynchronized with the phenology of their food. Ornithological studies have provided some of the best examples regarding the impacts of recent climate change on wildlife from around the world (Crick and Sparks 1999, Crick 2004). One potential problem with correlation studies is there may be a publication bias towards reporting advances in timing of breeding because of the general expectation that climate change should cause advancements, rather than publication of a lack of trends, or even delays in nesting (Both et al. 2004).

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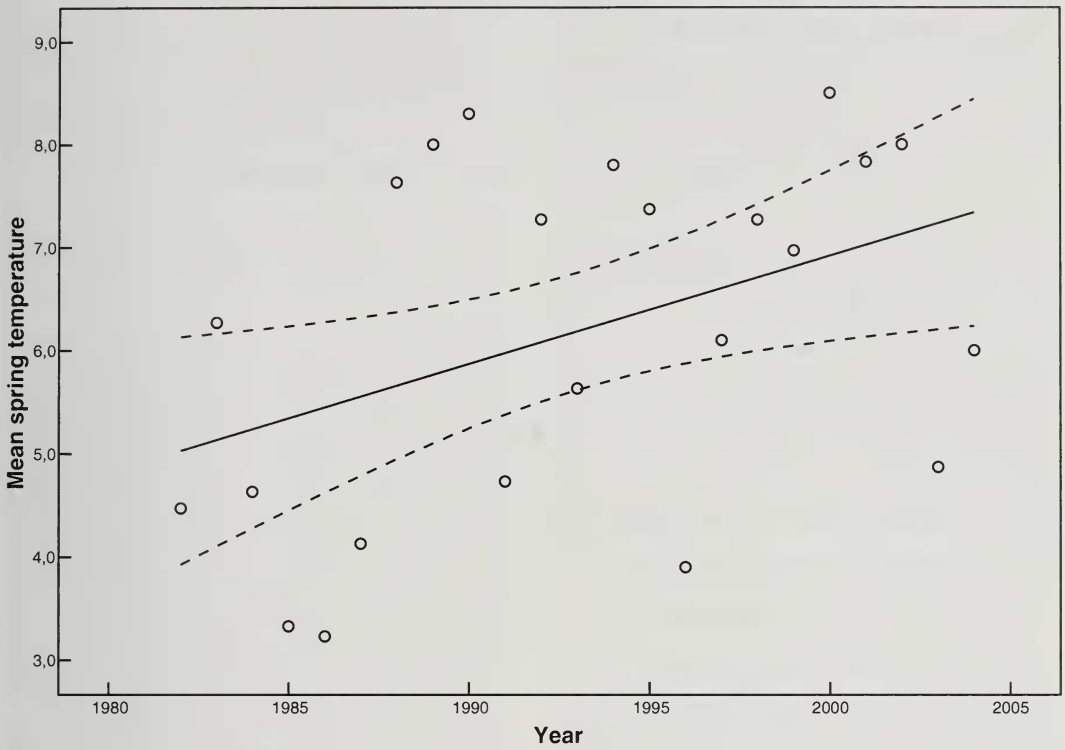

FIG. 2. Correlation between spring temperatures and year for Blue Tits in Mokrice, Croatia, 1982 to 2004 (Pearson's correlation coefficient: $r = 0.417$, $P = 0.048$, $n = 23$; $y = -203.08 + 0.11x$) (dashed lines represent borders of 95% confidence interval).

improve this manuscript. I also thank the Meteorological Office in Zagreb for providing the spring temperature data.

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